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Arctic clouds in the ECMWF forecast model: an evaluation of cloud parameterization schemes

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The Arctic is experiencing significant changes and is an important part of the global climate, which needs to be understood and accurately represented in both climate and weather prediction models. Mixed-phase clouds are an integral part of the Arctic system, for precipitation and for their interactions with radiation and the local thermodynamics. Mixed-phase processes are often poorly represented in global models and many use an empirically based diagnostic partition between the liquid and ice phase that is dependent solely on temperature. However, increasingly more complex microphysical parameterizations are being implemented allowing a more physical representation of mixed-phase clouds.

This study uses in situ observations from ASCOS campaign in the central Arctic to evaluate the impact of a change from a diagnostic to a prognostic parameterization of mixed-phase cloud and increased vertical resolution in the ECMWF Integrated Forecast System (IFS). The newer cloud scheme improves the representation of the vertical structure of mixed-phase clouds, with supercooled liquid water at cloud top and ice precipitating below, improved further with higher vertical resolution. Increased supercooled liquid water and decreased ice content are both in closer agreement with observations. However, these changes do not result in any substantial improvement in surface radiation and there remains a warm and moist bias in the lowest part of the atmosphere. Both schemes also fail to capture the transitions from overcast to cloud-free conditions. Moreover, whereas the observed cloud layer is frequently decoupled from the surface, in the model the cloud remains coupled to the surface most of the time. The changes to the cloud scheme are an important step forward in improving the representation of Arctic clouds, but improvements in other aspects such as boundary layer turbulence, cloud radiative properties, sensitivity to low aerosol concentrations and representation of the sea-ice surface may also need to be addressed.